by the Weather Bureau to the scale of 1:20,000,000, a corresponding rectangle cut from the butterfly map looks so similar that only an expert can tell the difference. When it comes to a regional map of very large scope such as the whole of Asia a rectangle cut from this world map gives a *better* representation than can be found in any atlas.

I have now before me about a score of national or local synoptic charts from the various national weather services of the world. Naturally, they are drawn to the most suitable projection for each particular country. Yet rectangles cut from the butterfly map are so nearly identical to these local regional maps that if some fine morning the latter blanks were substituted in any observatory for the former, it is doubtful whether the office force would be aware of the change.

If therefore rectangles of the right scope from the new map were gradually substituted in all weather bureaus (with the reforms and unifications much needed in many particulars), a very notable twofold result would thus be achieved at one stroke with very little cost or trouble.

First, would be the much needed international standardization as to symbols, scale, projection, printing, paper, and technique generally which at present show the utmost diversity.

Secondly, the astonishing result consequent on this substitution—namely, that all the recorded charts no matter what the scope or where the locality would, when pieced together according to the dates, form *a series of world maps for every day in the year*, or oftener as time goes on and the services of the world extend the network of observations.

To carry out this splendid program all that is necessary is to get the leading observatories to replace the local charts now in use with charts taken from the new map. The original cartoon should be executed to the scale of 1:10,000,000 with a reduction by photolithography to 1:20,000,000 for large countries or groups and a further reduction to a scale of 1:40,000,000 for insets. No other size or scale need be used.

With regard to the rectangles selected for local synoptic charts, and to select these with some definite system it is to be noted that, starting with meridian 22½° west of Greenwich every forty-fifth meridian therefrom around the world (eight in number) is a straight line from pole to pole about which the other meridians are symmetrically grouped in curves alternately convex and concave. The new national synoptic charts might well be inclosed in rectangles whose sides were successively parallel to these eight axial meridians. But the axial meridian need by no means necessarily be in the center of each rectangular synoptic chart.

Those here shown to the scale of 1:40,000,000 are slected on this principle but somewhat to one side of the vertical or central meridian.

As for the upper and lower borders, these also can be extended ad lib. to cover whatever area is needed.

In conclusion let me point out that the graticular internal weave of the conformal variant of the butterfly map belongs to the rhombic type of projection and that its details have been computed and its theory expounded by Dr. Oscar S. Adams of the United States Coast and Geodetic Survey, the foremost exponent of this, the very last word, in mathematical cartography.

I am not urging its adoption as a world map in competition with any existing program of the Comité International Meteorologique. However, learning from Professor Van Everdingen and Doctor La Cour that there is no move on foot to reorganize the national synoptic charts now in use, and that "each nation is perfectly free to adopt any map it chooses for local purposes." I hereby strongly urge the substitution of similar charts cut from this map to replace those now in use. To this end, if the United States took the initiative, I feel sure the other nations of the world could be persuaded to follow suit in view of the consequent advantages. It would then be in order to appoint a subcommission of the international committee to reorganize the whole subject of synoptic charts with a view to international cooperation and uniformity, resulting finally in daily weather records for the whole world, each on a single map of the whole world, in accord with the aims of the Pomona resolution.[1]

I present below as Figure 2 the rectangle "cut" from the butterfly map that was selected by Doctor La Cour and drawn in Copenhagen. Regarding this chart Doctor La Cour expressed himself in a letter to the author in the following words:

> My interest in your world map is so far limited that my duty only consists in the construction of weather charts over the North Atlantic and the adjacent coasts. Intentionally I have refused to elaborate charts for other parts of the world, but to meet the wishes of meteorologists and to facilitate for them the construction of supplementary charts, I am inclined to consider it expedient to use for the Atlantic, charts on a scale allowing other people to make use of your butterfly charts for other parts of the world.
>
> Much might be said in favor of the continuation of the projection used for more than 30 years for our file of North Atlantic weather charts. On the other hand the possibility for any one to augment the charts with other butterfly charts is of considerable interest. Wherefore, I have now made a trial in that direction and I send you under separate cover a copy of such chart over the North Atlantic.

98 (084.3)

A NEW PROJECTION FOR THE WORLD MAP

THE POLAR EQUAL AREA [2]

By J. Paul Goode, University of Chicago

The need of an equal area projection for the world map which would show true space relations across the North Pole, and for all the continental lobes across the Equator as well, was the necessity which was the mother of an invention of a new projection here presented. Last July Mr. George Findlay Simmons, curator in ornithology in the Natural History Museum of Cleveland, Ohio, wrote me asking for such a projection. He is studying the hunting falcons. These birds, with an apparent center of dispersal in western Siberia, show progressive differentiation covering the lands about the Arctic Ocean, and along lines of dispersal from these high latitudes over all the continental lobes to the south and across the Equator to the limits of the land.

Reluctantly I answered him that there was no such projection. There are projections which show true space relations across the North Pole; and all the ordinary

[1] At the Pomona College meeting of the American Meteorological Society in June, 1928, the following resolution was put and carried:

"Whereas the progress of meteorology and the science of weather forecasting are handicapped by the nonavailability of world-wide weather charts incorporating data for all parts of the globe from which observations are now procurable, and

"Whereas the various national meteorological services publish weather charts on base maps, the scales and projections of which do not conform to any agreed standard, therefore be it

"*Resolved*, That the council of the American Meteorological Society be requested to place before the Chief of the United States Weather Bureau the matter of securing an agreement among the several national weather services to the publication of weather charts of a standard scale and projection, so that those interested in the study of meteorology and weather forecasting may be able to fit the various individual maps together and thus have at their disposal a composite synoptic weather chart for any or all areas of the world from which meteorological observations are obtainable.

[2] A paper read before the Association of American Geographers at the New York meeting Dec. 28, 1928.

projections presenting the earth in the equatorial aspect would serve to show space relations across the Equator, but no one projection would do both. The need, however, suggested the following solution:

The principle used is an old one first enunciated, so far as can be found, by Jean Werner, of Nurenberg, in 1514 A. D.[1] Werner was translating and reviewing the latest "Ptolemy," as general map collections had been called for fifteen hundred years, and remarked that it was unnecessary to use the crude device of Ptolemy for a world map, since the problem of deploying the surface of the globe in an equal area projection could be done in three different ways. The first of these he developed, and it still bears his name. The projection is arbitrary, or conventional; it is strictly equal area; and it proves to be one of the most useful projections we have for geographic maps.

Werner thought only of presenting the earth's surface entire. And when his first idea was developed it provided a map of the earth's surface in a very interesting heart-shaped figure with a sharp sinus down to the North Pole and a sharp point at the South Pole. But though the angles, and therefore shapes, are perfect along the mid meridian, the angles become very acute toward the margin of the map, and therefore shapes are so sadly deformed as to make the projection of no value for map purposes as a world map. But it was very superficial judgment to condemn it on this basis alone. Yet, being condemned, it dropped out of consideration through the centuries.

The psychology involved is interesting. There is a Spanish proverb which expresses it: "Give a dog a bad name and hang him." The English have another saw which illustrates how difficult it is to rise above an evil reputation: "We have the name, we may as well have the game." None of the writers on projections gave it much consideration. Germain found some virtue in it, saying (p. 98), "Cette projection serait donc tout au plus bonne pour les regions voisine du pôle." But as late as 1882 our most distinguished authority on projections, Thomas Craig,[2] gives it a scant inch of space, saying for his last sentence (p. 75), "This projection is not of enough importance to spend any time in obtaining any of the formulas connected with it."

We need not at this time be too severe on Craig or other writers on projections. They have all of them been mathematicians first, and interested in projections mostly as intriguing problems to be solved. This projection is too simple to furnish grist for their mill.

Now a geographer comes to a projection with a different point of view. He is interested in it primarily as a means of providing a map for some definite use. Whether the making of it calls for much mathematics or none is a matter of no consequence to him. And it will be quite pertinent at this point to inquire what are the prime requisites in a projection for use in geography. And the answer is not far to seek.

The most important virtue a projection may have is that it provides an equal area map; that is, a map in which any square inch represents the same number of square miles of the earth's surface as any other square inch in the map. It is a pedagogical crime to enter areal distributions of any sort upon a map like the evil Mercator, which has not the equal area quality.

Next in importance to the equal area quality is that the map provide the best possible shapes to continents and other surface features. And that projection provides best shapes which depart least from the truth of angle and scale. On the globe all meridians cross all parallels of latitude at right angles. The ideal projection departs as little as possible from this right-angle quality. Conic and cylindrical projections provide absolute truth of angle, but may provide monstrosities as maps because of varying scale.

Now to look more intelligently at the projection proposed by Werner, it will be observed that angles and scale, and therefore shapes, are true along the mid meridian from the North Pole to the South Pole. And in high latitudes about the center of projection there is surprisingly little departure from the truth of angle, even in a wide range of longitude. It was the discovery of these fine virtues which led the author in 1910 to choose this projection for his wall map of North America[3] in spite of the evil reputation which had been unjustly saddled upon it from the beginning. The result is a map of North America which has strictly the equal area quality, and which in scale, angle, and shape compares favorably with the best result any projection can give.

So when the demand came for a projection which should deploy all the continental masses so as to keep true space relations across the North Pole, and on each continental lobe across the Equator as well, the virtues of this old discredited projection came to mind, and to it was brought at once the device of interruption of the grill of latitudes and longitudes, which has proved so valuable to the geographer, as applied already to other projections.[4]

This device interrupts the grill so as to give each continent or ocean a mid meridian of its own, thus assuring it of the best possible shape the projection affords. Applied to Werner's device, a wonderful result follows.

For the continents the North Pole is chosen as the center of construction. The three great continental lobes are deployed radially from the North Pole. Each continental lobe is given a mid meridian of its own, part of a radius from the North Pole. On each mid meridian true distances are pointed off for the parallels of latitude. Through these points, with radii from the North Pole, arcs of circles are struck for the parallels of latitude. On these parallels true distances are pointed off from the mid medidian for the positions of the merdians. Through homologous points on the parallels free curves are drawn for the meridians. It follows, since the parallels and the meridians are their true distance apart, that the projection has the equal area quality. It follows also that every point in the map is shown in its true distance from the North Pole.

Since this particular form of this project'on is devised to show land distributions, the lands are given the best shapes possible. So an extension of the idea of a mid meridian for the continent is introduced; that is, the mid meridian is allowed to migrate freely on any parallel of latitude to a position which will keep it in the middle of the land at that latiude. This provides surprisingly good shapes for the continents. North America is just about as good as any projection can give singly. South America is good, though "dished" a little on its northern shore because all the parallels of latitude are concave northward. Eurasia, in spite of its 190° spread of longitude,

[1] Germain, A.: Traité des Projections Geographiques. Paris: E. Thunot; 1865?

[2] Craig, Thomas: A Treatise on Projections; quarto, pp. 247. U. S. C. & G. S.; Washington, 1882.

[3] Goode, J. Paul. Wall map of North America; 46 by 66 inches. Chicago; Rand McNally & Co.

[4] (a) Interrupted Sinusoidal Equal Area. Copyrighted, University of Chicago, 1917. (b) Interrupted Homolographic Equal Area. Copyrighted, University of Chicago, 1918. (c) Homolosine, Equal Area, by J. Paul Goode. Copyrighted, University of Chicago, 1923.

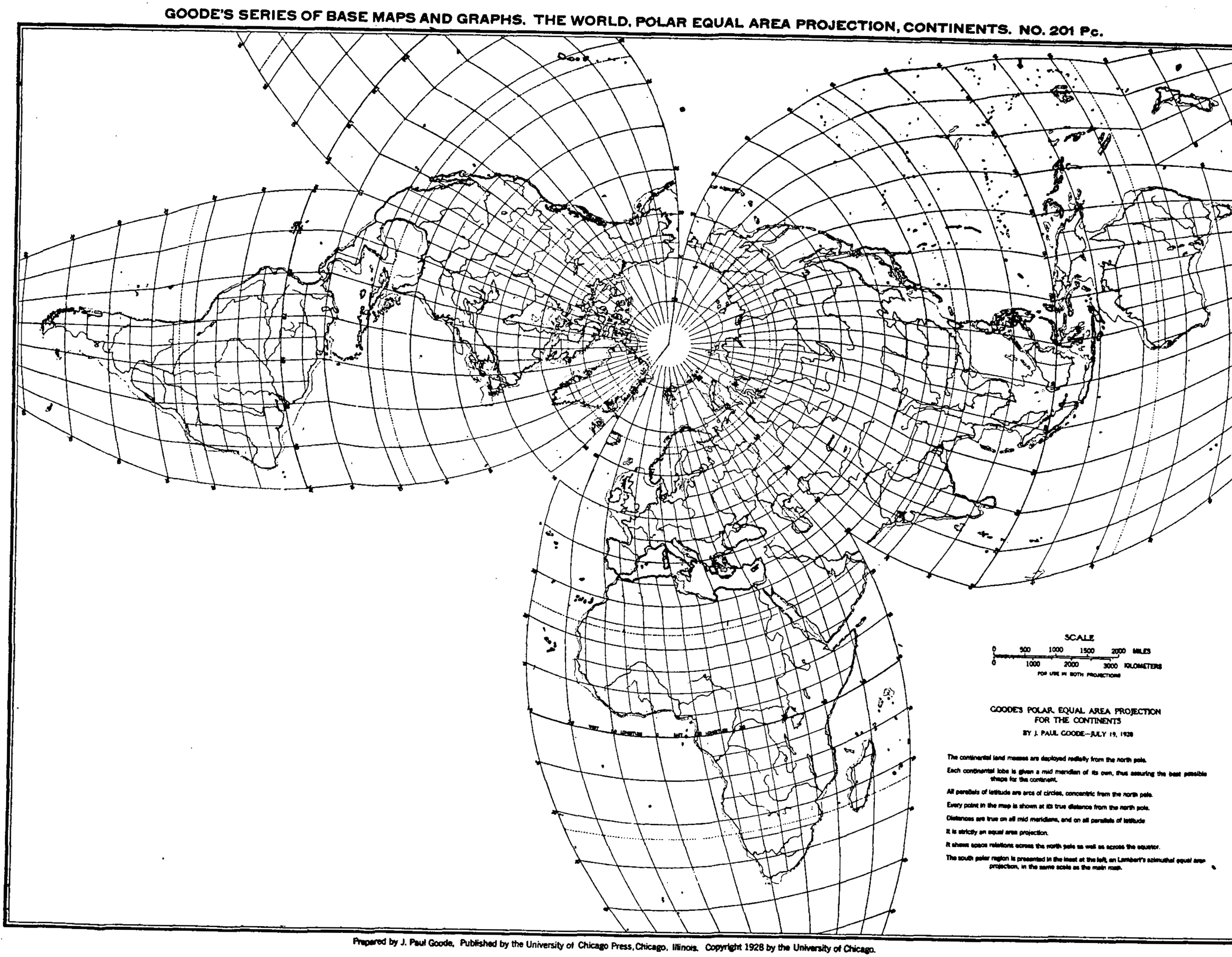

FIGURE 1.—The Polar equal-area projection

is almost as perfect as any projection can give separately. The same is true of the East Indies and Australia. Africa, though good, suffers a little in shape by having all its parallels concave to the north.

It will be observed that on the land areas the departure from right-angularity is so slight that a scale of miles can be used quite as well as upon any ordinary continental map. This is a rare quality in a world map; a great virtue.

The projection lends itself to all manner of areal distributions—in geology, paleontology, meteorology, climatology, botany, zoology, anthropology, and ethnology—where continental space relationship is important.

Where ocean unity is more important than continental unity, the projection lends itself quite as readily to the deployment of the oceans radially from the South Pole.

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EDITORIAL NOTE

The editor wishes to call attention to a series of four papers printed in the March, 1929, number of the Geographical Journal, London, as follows:

(1) A New Equal-Area Projection for World Maps, by S. Whittemore Boggs.

(2) A Retro-Azimuthal Equidistant Projection for the World Sphere, by Arthur R. Hinks.

(3) A Chart Showing the True Bearing of Rugby from all Parts of the World, by E. A. Reeves, map curator Royal Geographic Society.

(4) An Oblique Mollweide Projection of the Sphere, by Col. Sir Charles Close, president Royal Geographic Society.

The first of these papers describes a new equal-area projection which should be useful for statistical purposes. The map is an equal-area projection partaking of the qualities both of the equal-area projection of Sanson and the elliptical equal-area projection of Mollweide and being somewhat an improvement on both. The angular distortion is less than in Sanson below latitude 62° and less than Mollweide above 68°.

The projection is described by the author as follows:

> Since a flat map can not be made to represent the shape of large portions of the earth's surface perfectly, no name has heretofore been given to the property of good representation. The term "eumorphism" might, however, be appropriately applied to connote good shape of areas, just as orthomorphism is used to signify true shape in small areas. Eumorphism (i. e., approximate orthomorphism in large areas) would be characterized by approximation to rectilinear intersection of parallels and meridians and by the approximation to equality of linear scales along the parallels and meridians or along all parallels and at least a central meridian.

The second paper, by Mr. Hinks, had its beginnings in the invention by Mr. J. I. Craig of the Egyptian Survey of a projection which showed the azimuth of Mecca at any point on a map of the Muhammadan East, thus opening up a new class of projections, the retro-azimuthal, which preserve the true azimuth of any point from the center of projection. The retro-azimuthal, on the contrary give the true azimuth of the center from any point, a quality useful to the Muslim in showing the bearing he should assume for his prostration to Mecca, and to the surveyor in giving the azimuth on which he must set his frame aerial to get a distant station sending time signals.

The third paper, by Mr. Reeves, describes an effort to show the curves of Equal Reverse Azimuth of Rugby and so to produce a chart somewhat similar in general appearance to the Admiralty chart of the world showing Curves of Equal Magnetic Variation, but giving the true bearing of Rugby from all parts of the world instead of showing the variation of the compass.

The fourth paper, by Col. Sir Charles Close, is largely mathematical in which the author has computed the coordinates of a network for meridians and parallels at every 30°.

For the details of the paper the reader must be referred to the original.—*A. J. H.*

WET AND DRY NORTHERS

551.55 (73)

By I. R. TANNEHILL

[Weather Bureau office, Galveston, Tex., April 1, 1929]

There has been considerable discussion of the term "norther." In the northern half of the country the severe cold wave is called a "blizzard" but in the parlance of seafaring men it is a "northwester." In the south, even among seamen, a cold wind from a northerly quarter is commonly referred to as a "norther." Some early voyagers over Central American waters termed them "norths." (1) There is undoubtedly a sound basis for this distinction. The average path of cyclones and anticyclones determines largely the frequency of winds from northwest and north. As a result, northwest winds are more frequent in the northern half of the country than those from the north, while in the south the true "norther" predominates.

Cyclonic depressions, passing over or near the northern locality, with considerable frequency, cause northwest winds in their rear, quickly giving way as a rule to the variable or shifting winds with the passing of the center of the anticyclone. Winds from the north are of relatively short duration.

The change of wind to a northerly quarter in southern sections is produced mostly by the southward drift of anticyclones which form or follow in the wake of the depression. As the anticyclone drifts eastward or southeastward with center to the northward, the winds change more slowly from northwest to northeast and the duration of winds from true north is therefore much greater than in northern districts.

In the Annual Report of the Chief of the Weather Bureau, 1896–97, pages 110–123, there appears a record of average duration of wind from eight points of the compass for a 5-year period, 1891–95, inclusive. From this record I have computed the ratios of durations of north to northwest winds for a number of stations and these are shown in Figure 1. The geographical distribution of these ratios is evidence of the relatively greater frequency of true north winds in southern latitudes. On the Pacific coast the prevailing westerly wind obscures the effect of average cyclonic travel but east of the Rockies it is clearly seen. The greatest frequency, relatively, of north winds is found on the middle Gulf coast where the east/west contour of the coast line is evidently an added influence favoring winds from true north.

It is probable that this high frequency of true north winds is prevalent in the winter season over the whole of the Gulf of Mexico, the western Caribbean Sea, and much of the adjacent land areas. Over this region the term "norther" is commonly used (2) since it more